# UNIT TWO: ADAPTATION

## Introduction

The National Park Service has a mandate to protect the ecosystems within its boundaries. This includes both modern and ancient environments. Each provides an important story of the earth and how its organisms have responded to change.

The study of organisms from ancient worlds can help us learn about our own modern world. By understanding how ancient organisms lived and died we can gain new insights into how living things cope with their environments today and how their survival (and ours) depend on the consequences of our actions.

This unit introduces students to relationships of organisms, both fossil and modern, with their environment. It will encourage them, through making and recording their own observations about fossils and the rocks in which they are found, to ask questions about ancient and modern examples of adaptation. On short field trips around the schoolyard or neighborhood, students will observe how modern plants and animals are adapted to their environments.

## Objectives

Upon completion of this unit students should be able to:

1) discuss what fossils are and what they can tell us about the past;

2) list at least three things that can be learned about ancient environments and extinct organisms by studying rocks and fossils;

3) describe some comparisons that scientists make between fossils and living organisms;

4) stress in their conversation that ancient animals and plants were adapted to their environments just as modern ones are; and

5) emphasize how changes in environment (climate, topography) resulted in extinction of plants and animals in the past and will continue to do so in the future.

## VOCABULARY

**Carnivore** (kar-ni-vore) An animal that eats other animals.

Climate The history of rain, snowfall, and temperature, for an area. The average weather.

Coprolite (ko-pro-lite) Fossilized dung.

Environment Conditions in which an animal or plant lives. Consists of two parts. The physical part includes air, water, climate, soils, and topography. The biotic part consists of all other living things in that environment.

**Extinction** Extinction occurs when every member of a certain species of plant or animal dies.

Fossil Any naturally-occurring evidence of past life.

Habitat Where a plant or animal lives.,

Herbivore *(her-bi-vore) An* animal that eats plants.

Omnivore (om-ni-vore) An animal that eats both plants and animals.

Paleontologist (pay-lee-on- toko-jist) A person whose job is the study of fossils and ancient life.

Paleontology (pay-lee-on- toPo-jee) The study of fossils and ancient life.

Sediment Naturally-occurring material transported and deposited by water or wind, such as mud, sand, or peat.

Sedimentary rock A rock made of compressed and cemented sediment.

Species (spee-seez; sing. and pl.) A group of closely related plants or animals.

Trace fossil Fossil evidence of an activity of a living thing. Examples: footprint or coprolite.

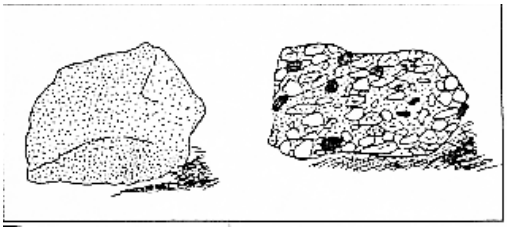
## Environments of past and present

The record of past life is more easily understood if we are able to refer to modern living things that we can observe directly. Perhaps the most important message to convey to young students just beginning their study of paleontology is that we can learn much about our own world by studying worlds of the distant past. It is often said in the geological sciences that "the present is the key to the past" (the geological principle of actualism; see A *Trip Through Time* by Cooper, Miller, and Patterson, reference on page 34). It is also true that what we know about the past can tell us a lot about the present.

An important concept in this unit is that of environment. An environment is defined as all the influences, both physical and biotic in nature, which affect an organism. The climate is part of the physical environment as well as the topography, soils, and water. The biotic environment includes all other organisms living in a given environment. Thinking environmentally means that no organism can be considered in isolation from any other element of its environment.

Adaptation is another important topic. Many examples of adaptation of organisms to their environment can be seen in nature. Some of the most successful organisms have very strong specializations for a specific environment. A fish, for example, is adapted to the aquatic environment. It has gills to exchange oxygen and carbon dioxide from water, fins and a streamlined body to swim through the water. It is well adapted to its environment and would be quite out of place on land. As another example, most birds have very specialized adaptations for flight. But with a little thought it will become obvious to students that different birds have unique specializations beyond those required for flight: although both a duck and a hawk can fly well, they are quite different. A duck is adapted for life in the water as well as the air, and has adaptations like webbed feet for swimming and a flat bill for straining food out of the water. A hawk, on the other hand, has adaptations like a sharp beak and talons for grabbing prey, and good eyes that enable it to hunt from the air.

## The fossil and rock records



Evidence about ancient living things and their environments comes from studying rocks and the fossils contained in them. Children can make some basic observations pertinent to understanding depositional settings, a basic part of understanding the origin of fossils. One of these is grain size. Coarse-grained sedimentary rocks generally originate in energetic settings like rapidly-flowing rivers. Fine-grained sediments are deposited in less-energetic settings. Students can observe this in modern environments when they compare sediments of a fast-flowing stream with those of a sluggish stream or lake. They can then draw some basic conclusions about the sedimentary. rocks in their collection. You may want to consult a field guide or one of the books listed at the end of this chanter for tips on rock identification.

A similar comparative approach is possible with fossils. Adaptation to environments can be seen in the fossil record as well as in the modern world. Paleontologists rely on comparisons between fossils and modern living things to understand the ways of life of ancient organisms. For example, a wing is adapted for a definite function (flight) and has a structure that can be recognized in fossil bones ac wall ac those of mnriarn birds A hat has a similar structure hilt it is cnm-

## Materials included in the kit

slide carousel: environments and adaptations magnifying lenses casts of modern animal bones and fossils: fossil carnivore (blue tag) fossil herbivore, (green tag) fossil omnivore, (black tag) modern carnivore: coyote jaw (yellow tag) modern herbivore: rabbit jaw, (orange tag) fossil fish casts slab of rock from Green River Formation

## Optional materials

cameras and notebooks for field trip

posed of a different arrangement of bones. We also recognize bats as fossils. Even if there were no fossil birds or bats, we would still know by their differences in anatomy that these two groups had different ancestors and different histories. The fossil record confirms what we suspect from studying the modern animals. Bird wings and bat wings are called analogous structures because they have similar functions but different origins.

Structures that use the same body part in different organisms and which may be used for different purposes are called homologous structures. For example, the bones in the front leg of a dog match one-for-one the bones in a human arm.

## Adaptation and changing environments

Environments are not static things. They are continually changing and have been changing throughout Earth history. Evidence for past environmental change abounds in the rock and fossil records. If change is gradual, organisms can adapt to the change or move to other more suitable areas. Abrupt change is more difficult to **cope with, and** organisms that cannot keep up with it face extinction. At numerous times in the geologic past, there have been widespread extinctions affecting organisms on a world scale. We know that in many cases these "extinction events" were the result of large-scale environmental change, but in most cases the evidence from the ancient record is inconclusive. Thus, for example, reasons for extinction of the dinosaurs at the end of the Cretaceous are speculative. There were probably many causes rather than one.

Extinction is a topic of fundamental importance not only with regard to fossils, but also when discussing modern living things. Largely as a result of human activities, environments are changing today at rates unprecedented in Earth history. Globally, the composition of the atmosphere has been altered by the addition of man-made compounds and carbon dioxide from the burning of carbon-based fossil fuels. This affects the absorption of sunlight, which has the effect of changing the climate on a massive scale. Locally, environments are being irrevocably altered by urbanization practices and the clearing of land for agricultural use at the expense of wildlife habitats. As a result, extinctions are occurring today at rates never before seen. We cannot tell what the long-term consequences of our actions will be. Whether a major event on the scale of the demise of the dinosaurs is in progress is a serious point that we should think about.

## Pre-questions

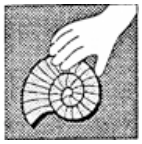
1. **What is an environment?** *An environment is the "world" of a living thing. It includes both living and non-living parts. Refer to the discussion in the Overview.*

2. **What is your environment like? This** *question can be used to start children thinking about how their own world is similar to or different from that of animals, both living and ancient. Get them started by having them describe their home, city, countryside, family and friends.*

3. **What kinds of animals and plants live with you in your environment?**
   *Have them describe their natural environment. This is a good question to ask before and after a walk in a neighborhood park.*

4. **What is a fossil?** *This question will test the students' pre-knowledge about fossils by encouraging them to come up with examples. If they mention only dinosaurs, tell them that not all fossils are dinosaurs. Challenge them to think of other examples in the coming weeks.*

4. **What can we learn from studying fossils?** *We can learn what living things were like before we were here. Importantly, fossils can tell us about animals and plants that are alive today.*



## ACTIVITY 7 Slide presentation

This brief slide presentation has been prepared to help introduce students to the concepts of environment and adaptation. You should prepare them by first introducing those terms and any others in the vocabulary list on page 20 that you think the students do not already know. The slide presentation will then reinforce those ideas.

The black-numbered slides are keyed to the following narrative. Read the text as you show the slides, stopping to explain points or to ask or answer questions. Ideally, this should be done with as much interaction with the class as possible. Let the students contribute their thoughts on the pictures, too.

1. TITLE ..... The environment is the world we live in. An environment has two parts. The first part is the physical part air, water, soil, and climate. The second part includes all the other plants and animals.
2. INTRO ..... There are many different kinds of environments on Earth and different kinds of living things are at home ..... each one. Let's look at a few different environments and some of the animals and plants that live in them.
3. PRAIRIE ..... The prairie,
4. OCEAN SURF ..... the ocean,
5. GLACIER NP ..... the mountains,
6. BIGHORN BASIN ..... the desert,
7. GRINELL LAKE ..... a lake. All are environments. And each is a place where different plants and animals live.
8. BADLANDS NP ..... Some environments are rugged.
9. WYOMING PLAIN ..... Others are flat.
10. BIG TREE ..... Some are cold.
11. FLORIDA PALM ..... Others are warm.
12. KEITH COUNTY ..... They may be dry,
13. ALLIGATOR ..... or wet. Animals and plants have special ways to survive in their environments. These are called adaptations.
14. BISON, YELL NP ..... The wooly coat of the bison is an adaptation that allows it to survive harsh winters and summer heat.
15. PRAIRIE DOG ..... Prairie dogs spend the winter underground in hibernation. They are especially adapted because they can ..... burrow and dig themselves a home.
16. BIRD ……, What special adaptation do birds have? That's right. They can fly. And so most birds are at home in the air. Environments are animals' homes. But other living things are also part of their environments.

17. ANTELOPE ..... Some plants and animals are adapted to compete with the other living things in their environments. Some have horns or antlers for competing with other members of their own species for territory or mates.
18. RABBIT ..... Others are fast runners.
19. KANGAROO
20. PORCUPINE ..... Some animals
21. PRICKLY PEAR ..... and plants have spines for protection.
22. RATTLESNAKE ..... Some have poison, like the rattlesnake
23. SCORPION ..... and the scorpion.
24. GIRAFFE ..... It is also very important for animals and plants to be able to get enough food to live. That's why many living things have very special adaptations for gathering food. The giraffe has a long neck so it can eat leaves from tall trees.
25. ANTEATER ..... The anteater has a very long tongue to collect ants from their nests.
26. CHIPMUNK..... Chipmunks collect food in pouches in their cheeks. There are many other ways living things are adapted to the world they live in. Can you think of some?
27. FOSSIL 1 ..... Animals and plants that lived many years ago were adapted to their worlds just as plants and animals are today. We know about plants and animals of the past because of fossils.
28. FOSSIL 2 ..... A fossil is some evidence of a plant or animal that has been preserved for many thousands or millions of years.
29. PALEONTOLOGIST……..A person who studies fossils is called a paleontologist. Paleontologists learn about ancient animals by looking at shells, bones, and teeth of fossil animals,
30. PLANT FOSSIL ..... and at stems, roots, and leaves of fossil plants.
31. FOSSIL IN ROCK ..... They also learn about what the environment was like by studying the rocks that fossils are found in. A paleontologist uses all information possible to learn about ancient worlds.
32. PARK RANGER ..... You can learn about fossils and ancient environments by visiting a national park or museum. You can ask the people who studied the fossils and rocks of the area to explain about what kinds of animals and plants used to live there, and what the environment was like.
33. SCENIC ..... Studying fossils might make you think how your own environment is like the ancient one. You might also find out that the environment has changed a lot.
34. SUMMARY ..... Fossils are interesting because they tell us about our world long ago. What can you learn from fossils?

## ACTIVITY 8
## Neighborhood field trip

A hike through the neighborhood, a local park, or a national park or monument becomes an experience in learning about adaptation if the class keeps its eyes open. Every living thing is adapted to its environment. Here is a chance to think about the environment and its physical and biotic parts.

Look at a tree, for example. Consider how this tree is adapted to the environment. Does it lose its leaves in the winter? Why? What does this tree need to survive? What is special about this environment that allows it to survive?

A common wild animal encountered in urban settings is the squirrel. Consider how this animal is adapted to its life in the trees. Its hind feet are specially jointed so that it can hold onto trees. Its teeth are adapted for a variety of foods. Like most rodents, its front teeth are chisel-like and good for gnawing. Its front feet are used as hands to grasp food as it is gnawed on. How would the squirrel survive in an environment without trees?

## ACTIVITY 9
## Discovering ancient environments

**Message** Paleontologists learn about ancient environments by studying both fossils and the rocks they find them in.

**Materials** Rock slab, fossil fish casts, hand magnifiers.

**Procedure**

1. **Study the fossils.** Pass out the fossil fish casts and the rock slab. Arrange the students in small circles around the specimens so that everyone has a chance to see them up close. Pass around the magnifiers and ask the students to look closely at the impression. Ask the students what they see on the surface of the cast. Most of them will recognize the impression as that of a fish. Explain that the fish.is a cast, but the rock is real. The rock is similar to rock that contains actual fossils. Ask them to describe the rock. Explain that it is a sedimentary rock, that formed when mud at the bottom of a lake settled into layers. When the fish died it sank to the bottom and was buried in the mud. After many years the mud was so deep that the water was squeezed out and the rock became solid.

2. **Travel back in time.** Ask the students to pretend that they can travel.back to the time when this rock formed. Have them guess what the environment is like. Tell them that the sediment that formed this sedimentary rock was deposited in a lake. What kinds of plants and animals lived there? Fish, obviously, and other lake-dwelling animals like frogs and turtles. Other animals that lived on the shoreline became fossils when they fell into the lake. Explain that a paleontologist would study this fish specimen and other fossils to learn about the other animals that lived with it in the lake. Paleontologists could learn about the physical environment by going out in the field and looking at all the sedimentary rocks that were deposited in the lake.

_. **Discuss what paleontologists do.** Tell the students that paleontologists use all the information they can find to learn about the environments of the fossils they find. Assure them that they have just made some important discoveries and when they go out in the field they will have opportunities to make some more.

# ACTIVITY 10 Learning about how ancient animals lived

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| Message | Paleontologists learn about how animals and plants lived in the past by comparing fossils with animals and plants that are alive today. |
| Materials | Casts of fossil jaws and teeth (carnivore-blue tag, herbivore-green tag, omnivore-black tag); casts of jaws of modern coyote (yellow tag) and rabbit (orange tag); hand magnifiers. |

**Procedure**

1. **Describe the carnivores.** Pass out the epoxy casts of fossil carnivore jaws (blue tag) and have the students look closely at them. Begin by asking them to describe the jaws. They may notice that the teeth are sharp, blade-like, or pointed, or that the incisors look like their own front teeth. Ask them to guess what this animal ate.

2. **Describe the herbivores.** Show them the casts of fossil herbivore jaws (green tag) and again ask them to describe them and guess what this animal ate. Have them compare the two types and suggest possible explanations for the differences.

3. **Talk about what paleontologists do.** Explain that paleontologists can make good guesses about what an ancient animal ate just by looking at its teeth. And that's good, because teeth are often the only part of an animal that is found as a fossil, because they are so hard. In fact, teeth are the hardest part of an animal's body. This is because (the students might like to speculate on this question) an animal's survival depends on its ability to nourish itself: teeth must be effective in food gathering and processing and must last along time-often, as in mammals, for the life of the animal.

4. **Introduce the modern jaws.** Ask the question: How do we know what animals eat and where they live? Explain that we know by direct observation, so we can use these observations to learn about the fossils. Show them the jaws of rabbit (casts with orange tag ) and coyote (casts with yellow tag) and ask them to compare them with the fossils they have just seen. Explain that the rabbit is a herbivore (it eats mostly plants), so its teeth need to be grinders to chew tough vegetation. Then explain that the coyote is a carnivore and needs its sharp teeth to tear meat into small pieces. Each animal's teeth fit its way of life.

   The same is true for the fossil animals. We know that the blue-tagged fossils came from a meat eater (carnivore) because its teeth are very similar to teeth of carnivores we see living today. The same is true of the green-tagged fossils (from a herbivore). Paleontologists use comparisons like these to discover how animals lived long ago.

   Omnivores (black-tagged fossil casts) are animals that eat both plants, like herbivores, and animal flesh, like carnivores. Like you, they need a little of each kind of food to be happy. Some carnivores might actually be better called omnivores. Pigs are good examples of omnivores. People have teeth useful for a variety of foods and are also examples of omnivores. Omnivores can often live in a variety of different environments and under a range of conditions, because they like to eat so many different things. But omnivores often have teeth that look like carnivores or herbivores, and for that reason it might be difficult to detect an omnivore known only as a fossil.

**Variations**
Study of adaptation is not limited to vertebrate fossils, of course. It is not always so easy to draw conclusions about whether many fossil invertebrates were carnivores or herbivores by looking at their remains, but many interesting observations can be made.

Fossil bivalves, for example, show a range of adaptations that make it relatively easy to determine lifestyle. Mussels are thin-shelled and blade-like, adapted for burrowing in mud or sand. Oysters are strong and thick-shelled and cement their shells to rocks, adaptations for life in the surf. Scallops have light, streamlined shells used for swimming. Some mussels extend threads out from their shells to attach themselves permanently to rocks.


# Field Trip

## yearning about adaptation from fossils

A field trip to a fossil locality can be an eye-opening experience for school children. They will collect all manner of curiosities, eagerly roaming beyond the earshot of the teacher and forgetting about the scientific goals of the day. Maintaining order will be the biggest challenge for the teacher. One way to make this job easier is careful planning.

Planning a field trip entails not only having distinct goals in mind, but also giving jobs to the students that will help in carrying out these goals. Thus, you should first state the goal of this field trip, "learning about adaptation from fossils," before leaving on the trip. Then ask the class to come up with ways that they can help in the project. Here are some ideas for dividing the responsibilities among the students.

**1. Writing a road log or journal**
A road log is a complete description of the itinerary of routes and stops in a field trip. Writing the log will be quite a bit of work and will require considerable help from the teacher, but it will be a big help in letting the students know what to expect.

The simplest type of road log is in a narrative form: "Leave Jones School and drive north on Highway 10 to the intersection with Highway 20. Turn right. Drive 12 miles to Smith Company Quarry. STOP 1. The Smith Company mines a rock called the White Mountain limestone at this quarry. It is Mississippian in age (280 million years old) and contains lots of fossil corals . . . ." Obviously some previous knowledge of the trip is necessary; it is up to the teacher to supply this information. Pre-running a trip of this sort where the class will be looking at rocks and fossils in the field is absolutely essential. Many books on regional geology or paleontology contain road logs that can be adapted for elementary-school use.

**Taking notes**
It is important to keep a record of everything that goes on when in the field. This is an important part of professional paleontology and geology. Assign small groups of students to keep notes on the different aspects of the trip. After the trip the students could compile their notes into a single field trip report. One group should be responsible for writing down where you visit and names of people you talk to. Another group could keep a record of fossils seen (or collected, if appro-

priate). Students working on the fossil list should write down the various adaptations of the fossils they record. For example, *"Exogyra,* oyster with very thick shell, probably to protect it from predators and strong waves. We think it was also adapted to sea water because it looks like modern oysters."

3. Photographing the trip Photographic documentation is another need of a carefully-run scientific expedition. It is also important to keep written notes of what was photographed and when photographs were made. These photographs can become a part of the field trip report.

• Professional help Planning and executing a field trip will be much easier if you can take advantage of someone who is familiar with the place of interest, especially if that person is trained in paleontology and has experience in education. That description fits guides and rangers at many national parks and natural history museums throughout the country. BLM resource specialists and interpreters may also be able to help. While the trip is in the planning stages, be sure to mention to your guide that you are studying adaptation and would like to see some examples of adaptations for specific ways of life, if any could be found. That way, he or she will have time to think about your class goals and to find some material to help illustrate what you have in mind.

On any field trip there will be numerous opportunities for diversion from the main theme. Depending on the situation, it may be best to stick to the theme until your major goals are accomplished, then handle the other interesting points.

## Post-questions

1. **What are the two parts of an environment?** *The Overview discusses the two parts: 1, the biotic (living) part, composed of all other organisms living there, and 2, the non-living physical part.*

2. How are fossils important to us? Fossils *are important to everyone because they tell us the history of our common past. Studying* fossils *helps us understand the world around us.*

*Questions 3, 4 and 5 would be good questions to pose to your guide when you visit a park or museum.*

3. What kind of animals and plants lived in the past at the national park, monument, or area that you visited? What do these fossils tell us about the environment at that time? Has the environment changed? How is it different?

4. How are the fossil animals and plants of the place you visited different from the ones living today in that same area?

5. Could you find places where the environment today is similar to the ancient environment at your field trip site? Where? *After your visit, you may get more ideas by studying the different environments of the world in magazines such as* National Geographic.

5. How do we know what ancient animals were like? *The main way scientists learn about ancient animals is to study their remains as* fossils.

7. **What happens to an animal or plant when the environment changes?**
*Some animals and plants may be able to live under a range of conditions and can survive changes. Others are less tolerant of changes and may have to move away. If an anima! or plant can neither adapt nor move away, then it will go extinct.*

8. **What are some ways that animals or plants can become extinct? Loss**
*of habitat (a place to live), change in climate (becomes colder or warmer, wetter or drier), competition with other species for food or habitat, overpredation (killed* off *by predators).*

9. **List some animals that are extinct. How many of these have become extinct recently?** *There are literally thousands* of *possibilities. Any animal or plant known only as a fossil, for example: dinosaurs, giant ground sloth, woolly mammoth, trilobites. Others have gone extinct in historic times: the passenger pigeon and dodo bird.*

10. **What are some things that humans do to the environment that might be bad for living things (including us)?** *Most children are aware* of *current environmental problems such as air and water pollution and waste disposal. Some might mention specific things like CFCs in aerosol cans, using too much water, or unnecessary driving.*

# Post-site Activities

**ACTIVITY 11**
**Compiling a field trip report**

To maximize learning from a field trip it is a good idea to have the class compile their findings in some form when you get back. This is also an opportunity for discussion and cooperation among the students.

Articles to include in a field-trip report include the road log, lists of fossils and their adaptations, and photographs with explanations. You might also include publications from parks, museums, and public lands that you visited.

## ACTIVITY 12 A picture story: How am I adapted to my environment?

Have the students each create a picture story from the point of view of a plant or animal (ancient, perhaps something learned on the field trip, or modern). Ask them to describe their environment in drawings: What is the environment like? What other kinds of plants and animals live with you? What are your special **adaptations that allow you to survive** in this environment? What do you like to eat? Are you a carnivore, herbivore, or omnivore?

After the students complete their drawings of their animal or plant at home in their own environment, ask them to do the picture story again in a "foreign" environment. Perhaps they could swap environments with a classmate. Most of these organisms may be unhappy, to say the least.

Follow up this exercise with questions, such as:

1. What are your chances of survival in this foreign environment? Why do you think so?

2. If you cannot live in this new environment what will happen to you? Have the children discuss chances of their survival. How likely is it that an animal would already have adaptations that would allow it to survive in the new climate? What would those adaptations be?

## ACTIVITY 13
## Discussing adaptation

Some of the best examples of adaptation are seen in adaptation to climate. Using pictures of different environments of the world, begin by talking about extreme environments. Show the class pictures of the arctic or antarctic and discuss the kinds of adaptations that are necessary to live in such a climate. Next discuss deserts such as the Sahara, the tropical rain forest of the Amazon Basin, the Great Plains of North America, coasts, salt marshes, mountain streams, alpine meadows. Each of these environments presents certain challenges to the organisms that live there, yet most of them contain a wealth of plants and animals that survive quite well under extreme conditions. By discussing these organisms in terms of their adaptations the class will gain an appreciation for their own environment.

This activity can be made into more of a cooperative exercise for the students. Have them bring old magazines from home *(National Geographic* and other natural history publications are especially useful). Go through the magazines in class looking for pictures that show different environments. Try to get a sampling of different extremes of climate and topography.

Change in environments is another important topic to discuss. It is sometimes easy to take the world's present environments for granted and assume that they have always been that way. But we know that is not true. Environments have changed in the past and they are always in the process of changing in some way. Environmental change is difficult for humans to understand because it often takes place so slowly that direct observation is difficult. Even the rapid changes that are taking place today as a result of human activity are hard to see. The fossil record contains a compressed view of many millions of years during which environments changed just as they do today. Change in the fossil record is therefore relatively easy to see.

[redacted]

Some topics that the class might cover with regard to environmental change include changing climates and the results of rapid climatic change. Consider each of the environments discussed when the class talked about adaptation. What would happen if that climate suddenly (in the course of years or decades) became much warmer or cooler? Related to this is the food supply. Herbivores rely on vegetation that lives in their environment. Plants are very sensitive to climate. What happens if a herbivore's favorite food disappears? What happens then to the carnivores that depend on that herbivore for their food supply? The discussion ex>nds to include the entire food web.

Present-day climate change is taking place on a large scale. The phenomenon of global warming from burning of fossil fuels is a topic of much public debate. Do the students understand the cause and effect relationship between driving a car and warming of the atmosphere? Burning of gasoline or any fuel containing carbon causes carbon dioxide (COz) gas to be released into the air. Carbon dioxide allows sunlight to pass through it and warm the Earth, but it does not let the heat radiate back into space. The more carbon dioxide in the atmosphere, the more heat is trapped. This causes the air over the whole Earth to warm. If the air becomes warmer everywhere, what effects will this have? What about the large ice caps that exist on Antarctica and Greenland? If all this ice melted, the oceans would rise several hundred feet and drown coastal cities. How many big cities near sea level can the students name? Look at a map for help.

Destruction of forests, much of it in the tropical (low-latitude) areas of the world where a very large number of plants and animals live, is responsible for the ongoing extinction of many thousands of species of plants and animals each year. The relationship between human activities and extinction is an important one to understand. So is the importance of maintaining the world's diversity of life. The class might discuss what their own stake in this crisis is and what they can do to help.

# National Parks and Monuments
# And Public lands

## Ancient adaptation

Examples of how ancient plants and animals were adapted to their environment can be found wherever fossils are well preserved and where evidence for the ancient environment is also present. In several national parks and monuments this information is interpreted for park visitors.

• **Stromatolites** Some of the rocks in Glacier National Park (in northwestern Montana) contain examples of some of the oldest fossils known. These fossils are strange cabbage-like mounds called stromatolites. The stromatolites in Glacier are at least 1.4 billion years old. Stromatolites form in quiet, shallow water by growth of mats of blue-green algae. Tiny filaments in the algal mat trap mud. Then the algae grow another layer on the mud. Growth is usually not uniform, but usually occurs at a faster rate in some areas, after time causing cabbage-like mounds to appear.

Stromatolites were more common 1.4 billion years ago than today because there were no "higher" animals such as snails or fish to feed on the algal mats. Thus, the blue-green algae were well adapted to life in the shallow sea and sometimes were able to form spectacular mounds. These structures, stacked one on the other in the rock unit called the Helena Dolomite, now make up entire mountainsides in Glacier National Park.

Stromatolites are also found in Fossil Butte National Monument and surrounding public lands in southwestern Wyoming. But we know that the rocks at Fossil Butte are only about 50 million years old. There were plenty of animals around at that time that would have eaten algal mats before they had a chance to form stromatolite mounds (see discussion of Fossil Butte in Unit 3, page 48). Clearly, then, most of the animals must have been somehow excluded from areas where stromatolites formed. What kind of environment was this to which primitive algae were adapted, but no higher animals? It appears that stromatolites formed during times when the lake was very salty. No fish or invertebrates could survive in the salty water and so the tough blue-green algae thrived, just as they did in the Precambrian, 1.4 billion years ago.

# References for further reading

*Search for the Past: An Introduction to Paleontology,* J. R. Beerbower, Prentice-Hall, 1968. (No ISBN) An older, but comprehensive, introduction to paleontology. Discusses principles. Illustrates most groups of invertebrate and vertebrate fossils.

*Dinosaurs and their Living Relatives,* The British Museum (Natural History), 1979. (ISBN 0-521-26426-X) Introduces cladistic taxonomy-how scientists classify living things on the basis of shared characters. Guides the reader using cladistic reasoning to discover the relationships of dinosaurs.

*Ancient Environments,* L.F. Laporte, Prentice-Hall, 1979. (ISBN 0-13-036392-8) Discusses sediments and sedimentary environments and how they relate to the environments of living organisms. A moderately-technical account of how paleoecologists reconstruct ancient environments.

*The Ecology of Fossils, W.S.* McKerrow, The MIT Press, 1978. (ISBN 0-262-13144-7) This book depicts communities of organisms in a chronological series of block diagrams from the Precambrian to the present. Most of the diagrams are cutaway views of the seafloor since the book's emphasis is on the marine, but some land and freshwater communities are also shown. Although technical in nature, this book would be fascinating to read by almost anyone interested in fossils or paleoecology.

*A Trip Through Time: Principles of Historical Geology,* 2nd edition, John D. Cooper, Richard H. Miller, and Jacqueline Patterson, Merrill Publishing Co., 1990. (ISBN 0-675-21134-4) Discusses principles including actualism (page 177).

**• Books for children**

*Be an Animal Detective,* Steve Parker, Derrydale Books, 1989. (ISBN 0-517-68023-8) This book is about modern animals, but has discussions of adaptation that will be useful in understanding some concepts in paleontology. Could be used for children in grades 2 through 5.

*Protecting Endangered Species,* Usborne Conservation Guide, Felicity Books, EDC Publishing Co., 1992. (ISBN 0-7460-0608-X) Discusses modern endangered species. This book would help children compare the fate of modern endangered animals with animals known from fossils that have been extinct for millions of years. Best for children in grades 2 through 4.

*The Usborne Book of Prehistoric Facts,* Annabel Craig, Usborne Publishing, Ltd., 1986. (ISBN 0-86020-9733) A whimsically-illustrated collection of isolated "amazing-but-true" facts and lists about ancient life.